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ABSTRACT

This study is limited to science and engineering doctorates (both PhD and Doctor of Arts) and spans the period 1969 to 1980--a period for which most of the factors likely to have a significant effect on the supply and utilization of doctorates are known or can be reasonably anticipated. The basic methodology involves statistically projecting past and current trends, including reasonable variations, into the future. Projections cover the areas of engineering, physical sciences, social sciences, life sciences and mathematics. They indicate an expected 315,000-336,000 doctoral scientists and engineers available to the US economy in 1980, compared to 270,000-297,000 available positions, and continuation of the movement away from graduate teaching and R&D activities as the major utilization of doctorates. The data are presented in charts and tables and are accompanied by discussion. (JS)

1969 & 1980 science & engineering doctorate supply & utilization

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Foreword

The relationship between the supply and utilization of scientific and engineering manpower pervades almost all aspects of science policy, as well as the planning and support of higher education. The time factors involved in the dynamics of this manpower system are long—an average of 11 years is required between college entry and the achievement of a science doctorate. In view of the significance of scientific manpower in a modern society and the length of the time required for its production, it is important to develop projections which can produce some insight into possible future situations. It must, of course, always be understood that *projections are not predictions*. Projections are derived from statistical models based on trends and an awareness of current happenings. Thus, they produce a range of possible future situations based on definitive assumptions and no significant break in trends. Actual events may well turn out to be different from some of these projections. However, by stating assumptions and methodologies explicitly, the effect of different variables can be better appreciated and taken into consideration in plans and policy determinations.

The National Science Foundation (NSF) prepared its last study on the projected relationships between supply and utilization of science and engineering doctorates nearly 2 years ago. At that time the Nation was already at the beginning of a period of readjustment of manpower relationships, student interests, and financial support. We are still in this period. However, uncertainties about the future and possible changes should not deter the making of projections. Rather these uncertainties emphasize the need for the periodic reexamination of projections, including the updating of data and a reassessment of assumptions. For this reason, the NSF not only initiated this reexamination, but will continue its study of the subject and will publish updated projections at suitable intervals.

The projections presented in this publication are complex and are based on a variety of data. Thus, it is important that no false sense of precision be attributed to numerical values in view of the limitations of the data and methodologies, the complexity of the system, and the unpredictability of future events. The last factor requires special emphasis since, by their very nature, long-term projections cannot take into consideration factors impossible to anticipate at the time the projections are made. These factors could include: unexpected changes in the rate of growth of the national economy, sudden changes in national priorities, drastic changes in student interests or in the mode of operation of institutions of higher education, etc. With an appropriate understanding of these uncertainties, projective analyses of this kind do produce broad indications of likely balances or imbalances, and do provide insight into the quantitative effects of various parameters.

In this study, the analysis has been expanded to include broad areas of science, the data base has been updated, and the projection methodology has been improved. Supply and utilization projections for the total doctorate group are difficult, but they

are even more difficult for separate areas of science, since here the uncertainties outlined in the previous paragraphs are accentuated. Notwithstanding these many difficulties, an attempt has been made to meet the expressed need of decisionmakers with an analysis by broad area of science, such as the physical sciences, though not specific fields such as chemistry.

The projections resulting from this study show a greater likelihood of an oversupply of doctorates than appeared to be the case 2 years ago. If current trends continue, some problems seem to loom, especially in such areas as engineering and social sciences. However, it should be noted that certain steps have already been taken, or suggested, which could produce significant long-run reductions in the supply of science and engineering doctorates. For example, the U.S. Department of Labor revised its procedures for certifying the immigration of scientists and engineers into the United States in February 1971. Thereafter, such persons must have a job offer for which domestic workers are not readily available, and their employment must not adversely affect the wages and working conditions of domestic workers. As another example, suggestions have been made to institute policies to encourage academic retirement closer to the usual 60-65 retirement age for professionals. Furthermore, it should be noted that preliminary statistics for the fall of 1970 indicate an absolute reduction in the first-year, full-time graduate enrollments in science and engineering.

Many alternatives will be possible in the 1970's, which will permit utilization of science and engineering doctorates in activities for which they are well qualified, but for which the supply has been inadequate in the past. These activities, which contribute significantly to our scientific, economic, and social progress, will frequently require training somewhat different from that generally supplied to current doctorates. For this reason, it is clear—not only from this study but also from recent experiences, developing societal needs, and student interests—that university programs and present degree structures must continue to be carefully reexamined and probably changed to some extent.

A study such as this receives valuable assistance from many outside sources. The NSF is especially grateful to the Bureau of Labor Statistics, the National Center for Educational Statistics of the Office of Education, and the expert external reviewers whose comments were important in making this a better report.

C. E. Falk
Director, Division of Science
Resources and Policy Studies

May 1971

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Introduction

Scope

The scope of this study—the likely supply and utilization of science and engineering doctorates over the next decade—involves two points, and also some limitations that should be made clear for a proper understanding of the study results.

First, only science and engineering doctorates are analyzed in this study.[1] Nonscience and nonengineering doctorates (e.g., Ed.D., M.D., L.L.B., D.B.A., Ph.D., in arts, humanities, history) and bachelor's and master's degree supply and utilization are outside the scope of this analysis. However, the term doctorate, as used in this study, includes the newer science and engineering doctoral programs (e.g., Doctor of Arts) as well as the more traditional Doctor of Philosophy (Ph.D.).

Secondly, the time horizon for the study projections is 1969 to 1980—roughly the average time from entering college to earning a doctor's degree. Most of the forces and factors that are likely to have a significant effect on the supply and utilization of science and engineering doctorates are known or can be reasonably anticipated. Factors not apparent now or within the next 3 or 4 years are unlikely to have a significant effect before 1980, both because of the length of time required to produce doctorates and because of the overwhelming historical evidence that the higher educational system is relatively slow in changing.

Purpose and Methodolgy

The purpose of this study is to contribute to a better understanding of the likely future by careful consideration of past and present trends. The methodological approach used avoids normative judgments and simply indicates what is likely to occur if past and present trends continue. This is not a forecast or prediction that the past or present should, or will, continue in the same way. Rather, this study provides a factual basis for analyzing what has happened and what is likely to happen so that more knowledgeable discussions can proceed on future policies and priorities.

The basic methodology employed in this study is that of statistically projecting past and current trends, including reasonable variations, into the future. This methodology places the past and the present "under a microscope" to understand better where we have been and where we are as a basis for projecting where we are likely to be—if no structural breaks with past and present trends occur. Some unexpected changes in trends will, undoubtedly, occur during the next decade, as they have in the past, but the nature of these is not predictable.

Methods and Assumptions

Looking into the future is always hazardous and judgmental (even though based primarily on past and present data trends, as in this study), and knowledgeable people do have honest differences of opinion. For this reason, the methods and assumptions used in this study are explicitly summarized below, along with their rationale. In addition, the reader is provided with a statement of the sensitivity of the results to each method and/or assumption. Should the reader's judgment differ from that utilized here, he can apply his own and thereby assess the extent to which a change will affect the projected results. The summary of the methods and assumptions utilized that follows presents those that were used (A) to project supply; (B) to project utilization; and (C) by the Bureau of Labor Statistics (BLS) to project the general economy and the gross national product (GNP) to 1980.

[1] For a projection of scientists and engineers at all degree levels, see U.S. Department of Labor, Bureau of Labor Statistics, *College Educated Workers, 1968-80*, BLS Bulletin 1676 (Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, 1970.)

A. Summary Of Methods And Assumptions Concerning The 1980 Supply Of Doctoral Scientists And Engineers

Method and/or Assumption	*Rationale*	*Sensitivity**
1. The number of science and engineering doctorates existing as of January 1969 but who die or retire during the 1969-80 period is based on standard Department of Labor death and retirement rates by age group and recent data on the age distribution for this population. (Cf. pp. 16,30)	General methodological approach of projecting past trends.	±1 percentage point change in annual average attrition rate over the 1969-80 period (1.9 percent) = ∓1,500 doctorates.
2. The number of science and engineering doctorates awarded during the 1969-80 period is based on extrapolation of past trends in the relationships (some lagged) between total bachelor's degrees, bachelor's degrees in a broad area of science, enrollment for advanced degrees in each area, and doctorates awarded in that area, with additional weight given the most recent data. (Cf. pp. 10-11, 25)	Same as above.	±1 percent change in doctorates awarded during the period = ±2,300 doctorates.
3. The number of science and engineering doctorates who are trained outside the U.S. and become available to the American economy during the 1969-80 period is estimated from a minimal count in the 1968 National Register projected to the 1969-80 period. (Cf. pp. 11-12, 25-26)	Same as above.	±1 percent change in this estimate = ±50 doctorates.
4. The number of science and engineering doctorates who are trained in U.S. institutions in the 1969-80 period and who leave the country to work abroad is estimated from recent data on the proportion of those earning doctorates in the U.S who expect to be employed outside the U.S., based on the National Research Council Doctorate Record File. (Cf. pp. 11-12, 25-26)	Same as above.	±1 percent change in this estimate = ∓200 doctorates.
5. The number of female science and engineering doctorates who are trained in U.S. institutions during the 1969-80 period but who withdraw from the labor force is estimated from the relation between females awarded doctorates since 1920 and the number of these in the labor force in 1968. (Cf. p. 26)	Same as above.	±1 percent change in this estimate = ∓60 doctorates.
6. The number of male science and engineering doctorates who are trained in U.S. institutions during the 1969-80 period but who die or retire is based on standard Labor Department death and retirement rates for the age groups represented by this population. (Cf. p. 26)	Same as above.	±1 percent change in this estimate = ∓26 doctorates.
7. Items 2-6 above determined the high incremental supply estimate. The low incremental supply estimate was calculated at 10 percent less. (Cf. p. 11)	2-6 above.	2-6 above.

*In terms of 1980 total doctorates

B. Summary Of Methods And Assumptions Concerning The 1980 Utilization Of Doctoral Scientists And Engineers

Method and/or Assumption	*Rationale*	*Sensitivity**
1. The number of graduate faculty positions varies directly with enrollment for advanced degrees in science and engineering extrapolated from past trends with additional weight given the most recent 3 years of data. The relationship was applied separately to each of the 5 broad areas of science. (Cf. pp. 14-15, 28)	General methodological approach of projecting past trends.	±1 change in the 1980 graduate science enrollment/graduate science faculty ratio (3.9) = ±1,700 doctorates.
2. The number of undergraduate faculty positions varies directly with undergraduate enrollment extrapolated by OE from past trends. The 1969 distribution by broad area of science were assumed to continue. (Cf. pp. 14-15, 28)	Same as above.	±1 change in the 1980 undergraduate enrollment/undergraduate science faculty ratio (57.7) = ±1,800 doctorates.
3. The number of nonacademic R&D positions in 1980 is equal to projected nonacademic R&D funding divided by the extrapolated cost per R&D scientist and engineer with additional weight given the most recent 3 years of data. The 1980 distribution by broad area of science was based on the BLS 1980 estimate of total scientists and engineers to which was applied the 1980 relationship between R&D to total scientists extrapolated from past trends. (Cf. pp. 13-14, 29)	Same as above.	±1 percent change in the 1980 nonacademic R&D funding=±800 doctorates. ±1 percent change in the 1980 R&D cost per R&D scientists = ∓800 doctorates.
4. The doctoral to total scientist ratio for graduate faculty increases about a percentage point every 2 years during the 1969-80 period going from 81 to 86 percent. This implies that 95 percent of new and replacement positions will be filled by doctorates. (Cf. pp. 15, 28)	Best available evidence is that the doctoral to total faculty ratio has been increasing about 0.8 of a percentage point a year over the past few years.	±1 percentage point change in the 1980 ratio=±900 doctorates.
5. The doctoral to total scientist ratio for undergraduate faculty increases one percentage point a year during the 1969-80 period, going from 36 percent to 47 percent. This implies that 62 percent of new and replacement positions will be filled by doctorates. (Cf. pp. 15, 28)	Same as above.	±1 percentage point change in the 1980 ratio=±1,600 doctorates.
6. The proportion of new and replacement nonacademic R&D positions filled by doctorates will range from a low of 10 percent to a high of 20 percent greater than the 1969 doctoral to total scientist ratio of 1:10. (Cf. pp. 15-16, 29)	Past doctorate utilization for nonacademic R&D was restricted by short supply.	±1 percentage point change in the increase in doctoral to total scientist ratio=±800 doctorates.
7. The number of postdoctoral positions varies directly with projected academic R&D funding. (Cf. p. 28)	Academic R&D funding is principal source of support for postdoctorates.	±1 percent change in 1980 academic R&D funding=±60 doctorates.
8. As a low, the number of nonacademic doctorates engaged in activities other than R&D in 1980 as a proportion of total doctorate utilization is extrapolated from past trends and increases from 10 to 15 percent. As a high, the 1980 extrapolated proportion is 19 percent. (Cf. pp. 15-16, 29)	Low: This is consistent with general methodological approach. High: Past doctorate utilization for nonacademic activities other than R&D was restricted by short supply.	±1 percentage point in this proportion=±2,700 doctorates.
9. R&D funding in 1980 is a low of 2.7 percent and a high of 3.0 percent of GNP. (Cf. pp. 14, 28)	2.7 percent of GNP is the estimated 1970 ratio and is the lowest this ratio has been for the past decade. 3.0 percent of GNP is the highest ratio ever attained.	±1 of a percentage point change in 1980 R&D funding as a percent of GNP=∓1,200 doctorates.

*In terms of 1980 total doctorates

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C. BLS 1980 Model of the Economy and GNP Estimate and Major Assumptions Utilized*

Projected growth in GNP is 4.3%/yr. between 1968-80 resulting in a 1980 GNP estimate of $1.490 billion (1969 dollars).

The above utilizes the following major assumptions:

1. The institutional framework of the economy will not change radically through the 1970's.
2. There will be full employment in 1980, with an unemployment rate of 3 to 4 percent.
3. The international climate will be improved. The United States will no longer be fighting a war, but the still guarded relationship between major powers will permit no major arms reduction. Defense spending, however, will be reduced from the peak levels of the Viet Nam conflict.
4. Armed Forces streng . will return to approximately the pre-Viet Nam level.
5. Economic, social, technical, and scientific trends will continue, including the values placed on work, education, income, and leisure.
6. Fiscal and monetary policies and an active manpower program will achieve a satisfactory balance between low unemployment rates and relative price stability without reducing the long term economic growth rate.
7. All levels of government will unite to meet a wide variety of domestic requirements, but Congress will channel more funds to State and local governments.

*Excerpted from Department of Labor, Bureau of Labor Statistics, *College Educated Workers, 1968-80, op. cit.*

Summary of Findings

General

The projection indicates an expected 315,000–336,000 doctoral scientists and engineers available to the U.S. economy in 1980, compared to 270,000–297,000 available positions (table 1). This represents a greater likelihood of a future oversupply than the previous NSF projections developed 2 years ago.[2]

Engineering

Wide differences in the projected supply-utilization situation in the various broad areas of science are illustrated in chart 1. The most serious potential imbalance is in engineering, where annual doctorates awarded as a proportion of existing doctorates are high—15 percent in 1969. This results in a projected 1980 supply of more than 40 percent in excess of the projected utilization (in terms of the middle of the ranges).

Physical Sciences

In contrast, annual doctorates awarded in the physical sciences are presently a relatively low proportion of existing doctorates in this area (8 percent in 1969) and no increase in annual awards is projected over the decade. As a consequence, projected 1980 supply and utilization are virtually in balance.

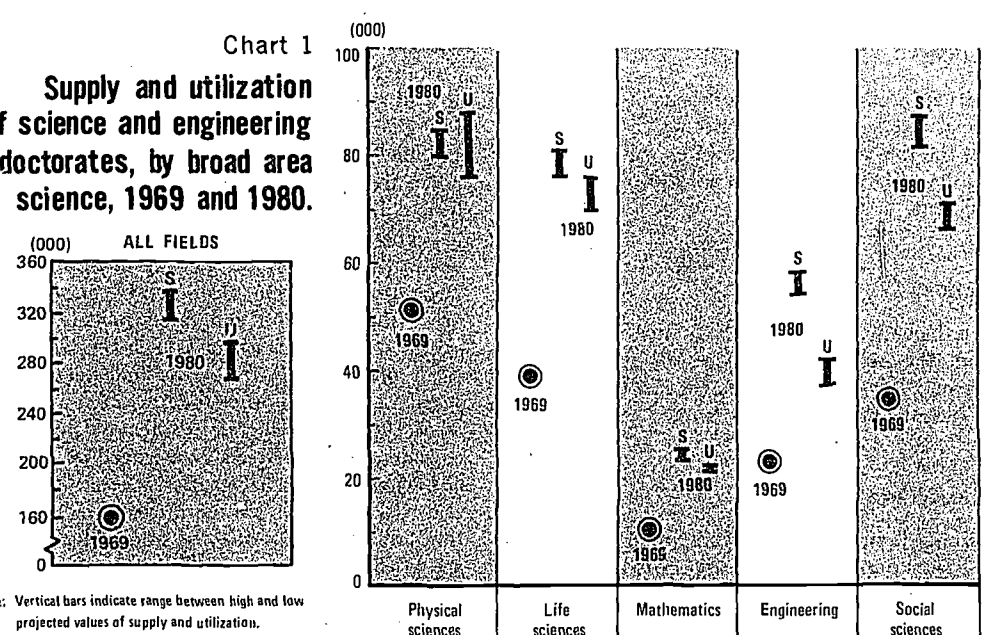
Social Sciences

In the social sciences the projected values show an

[2] National Science Foundation, *Science and Engineering Doctorate Supply and Utilization, 1968-80* (NSF 69-37) (Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, 1969.)

Chart 1

Supply and utilization of science and engineering doctorates, by broad area of science, 1969 and 1980.



Note: Vertical bars indicate range between high and low projected values of supply and utilization.

Source: National Science Foundation

Table 1.—SUPPLY AND UTILIZATION OF SCIENCE AND ENGINEERING DOCTORATES, BY BROAD AREA OF SCIENCE, 1980

[In thousands]

Level of supply/ utilization	*Total*	*Physical sciences*	*Life sciences*	*Mathematics*	*Engineering*	*Social sciences*
High supply[1]	335.6	84.4	81.1	25.2	57.6	87.3
Low supply[1]	314.8	80.1	76.2	23.5	53.7	81.3
High utilization[2]	297.4	88.1	74.5	21.9	42.4	70.5
Academic	165.1	28.7	53.1	18.3	16.5	48.5
Nonacademic R&D	77.3	39.1	14.0	1.1	14.6	8.5
Nonacademic other	55.0	20.3	7.4	2.5	11.3	13.5
Low utilization[2]	269.7	75.6	70.1	21.2	36.7	66.0
Academic	163.5	28.0	52.5	18.2	16.3	48.4
Nonacademic R&D	66.3	33.5	12.0	1.0	12.5	7.3
Nonacademic other	39.9	14.1	5.6	2.0	7.9	10.3

[1]High 1980 supply is based on the assumptions summarized on p. 2 above. Low 1980 incremental supply is calculated at 10 percent less than was estimated for the high incremental supply (p. 11).

[2]High 1980 utilization is based on the combined application of the higher assumptions concerning 1980 R&D funding, doctorate absorption into new and vacated positions, and growth in the utilization of nonacademic doctorates in activities other than research and development (p. 3). Low 1980 utilization is based on the lower assumptions concerning these factors.

oversupply during the decade due to the increasing rate at which social science doctorates are being awarded. The projection indicates a supply in excess of utilization by 1980 of over 20 percent in terms of the middle of the ranges.

Life Sciences

The situation in the life sciences is analogous to that in the social sciences but less extreme. The projected increase in the rate at which doctorates will be awarded during the decade would result in a 1980 oversupply of about 9 percent.

Mathematics

In mathematics, the smallest area of science represented, the projection indicates an oversupply of doctorates in 1980 of over 10 percent in terms of the middle of the ranges.

Overall Considerations

A warning is in order concerning interpretation of findings as they pertain to broad areas of science. Each such area includes a number of specific fields or disciplines (e.g., physics, biology, electrical engineering, economics, statistics) that may differ markedly from each other as regards their supply-utilization relationship. Thus, it must not be assumed that the aggregate situation for the broad area of science is necessarily applicable to individual disciplines.

Apart from the overall supply-utilization relationship, the study points up several probable changes in the pattern of science and engineering doctorate utilization over the next decade. Chart 2 shows that academic doctorates, as a proportion of total doctorate scientists, are not expected to change markedly over the projection period. However, there are important changes by broad area of science. In the physical sciences and engineering where a minority of doctorates are presently in academia and the projected growth in enrollment is less than in other fields, there are appreciable relative shifts away from college and university employment.

The projected relative shift away from R&D activities in the nonacademic sector is illustrated in chart 3, in terms of the percent of doctorates engaged in activities other than research and development. In the physical sciences, life sciences, and engineering, only relatively small proportions of nonacademic doctorates were engaged in activities other than research and development as of 1969. The projections still show minorities, though considerably larger ones, so engaged in 1980. In the social sciences and mathematics, where R&D activities and non-R&D activities are more evenly divided, the projections result in majorities of nonacademic doctorates in activities other than research and development.

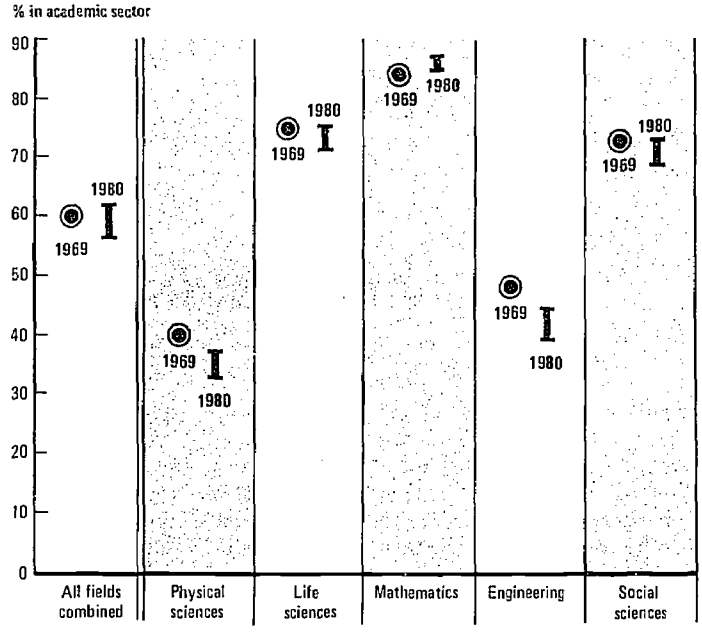
Within the academic sector, doctorates teaching undergraduates in 2- and 4-year institutions amounted to 40 percent of academic doctorates in 1969; this proportion is projected to increase to 47 percent by 1980.

In short, about two-thirds of all science and engi-

neering doctorates are now engaged in teaching and research in graduate schools, or are employed in nonacademic R&D positions. In contrast, slightly less than one-half of those doctorates entering employment in the 1969-80 period are projected to be in such positions. The other half are projected to be teachers of undergraduates or in non-R&D positions outside the academic world.

Chart 2

Science and engineering doctorates in the academic sector, by broad area of science, 1969 and 1980

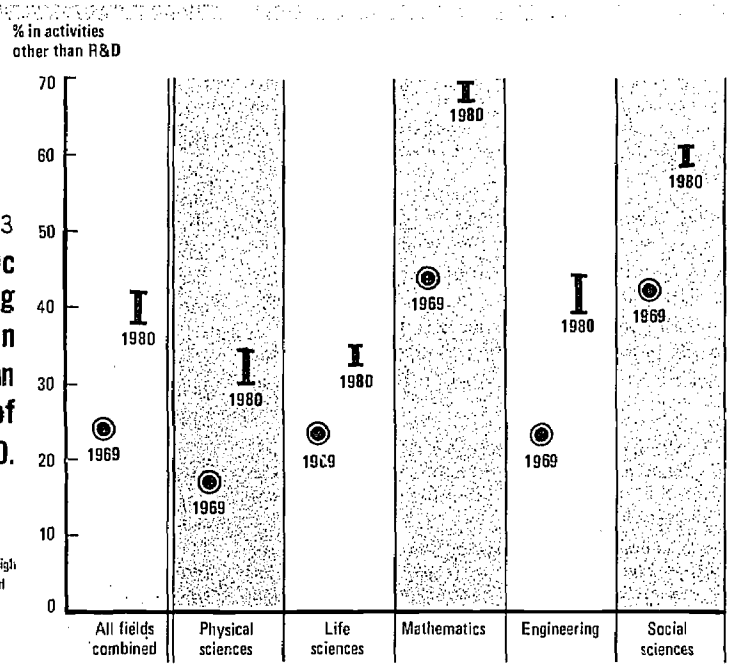


Note: Vertical bars indicate range between high and low projected values of supply and utilization.

Source: National Science Foundation

Chart 3

Nonacademic science and engineering doctorates engaged in activities other than R&D, by broad area of science, 1969 and 1980.



Note: Vertical bars indicate range between high and low projected values of supply and utilization.

Source: National Science Foundation

Implications of the Projections

An important factor in the projection levels is the continuation of the trend toward the growth of doctorates engaged in other than graduate teaching and R&D activities. Future growth rates for doctorates teaching undergraduates in 2- and 4-year institutions are projected to be considerably larger than those for graduate faculty. Thus, significant numbers of new doctorates are projected to be engaged in activities which are markedly different from those practiced by most present doctorate holders.

A problem inherent in this trend is expressed in the following:

> "Short of a national depression—which is not a part of my picture for the future—it is unlikely that any substantial number of persons with the doctorate will be unemployed despite the surplus conditions I foresee. . . . However, an increasing proportion of these specialists will not be employed in jobs for which they were trained or to which they aspire. . ."[3]

It seems advisable, therefore, to continue current examination of university graduate programs and degree structures to assure that they will be responsive to these somewhat different future needs for doctorate level scientists. Such an examination has already begun.[4]

The study results also imply the need to reexamine graduate science training in terms of the numbers of doctorates awarded. This is especially true in engineering and in the social sciences where the projected oversupply is greatest. An important consideration is the increasing tendency toward imbalance. The new projections show a greater likelihood of an oversupply than appeared to be the case 2 years ago—continuing the direction away from earlier forecasts of substantial shortages.

An understanding of the degree of uncertainty about a few of the important factors affecting the projections is essential. Lack of growth in Federal R&D funding continued through fiscal year 1971, but the proposed fiscal year 1972 increase[5] does represent a significant change. The present projections assume that this important factor in doctorate utilization will continue on the proposed upward trend beyond fiscal year 1972. However, such a trend has not yet been firmly established. and therefore, some degree of uncertainty persists. Concerning supply, it is still too early to gage the full effect of the sharp decline in Federal graduate traineeships on doctorate production. Neither is it possible to foresee whether the increasingly discussed suggestion for a lower retirement age in academia will gain momentum.

Because of the rapidly changing situation, it is important to revise projections periodically as new data become available. In this way, a number of successive projections can be studied, with particular attention to movement toward, or away from balance. The direction of this movement is a more sensitive indicator than the degree of imbalance indicated by a single projection.

[3] Allan M. Cartter, *Scientific Manpower Trends for 1970-85, and Their Implications for Higher Education.* Paper delivered at the meeting of the American Association for the Advancement of Science (Chicago: Dec. 27, 1970).

[4] See, for example, American Association of State Colleges and Universities, *The Doctor of Arts Degree, A Proposal for Guidelines,* Committee on Graduate Studies and *The Specialized Degree,* National Conference on the Intermediate Degree (Washington, 1970); Carnegie Commission on Higher Education, *Less Time, More Options in Education Beyond High School* (New York, 1970)

[5] The President submitted to Congress in January 1971 the proposal for an additional $1.2 billion in obligations for research and development over fiscal year 1971 levels; see Executive Office of the President, Office of Management and Budget, *The Budget of the United States Government, Fiscal Year 1972* (Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, 1971.).

Utilization of the 1969 Supply

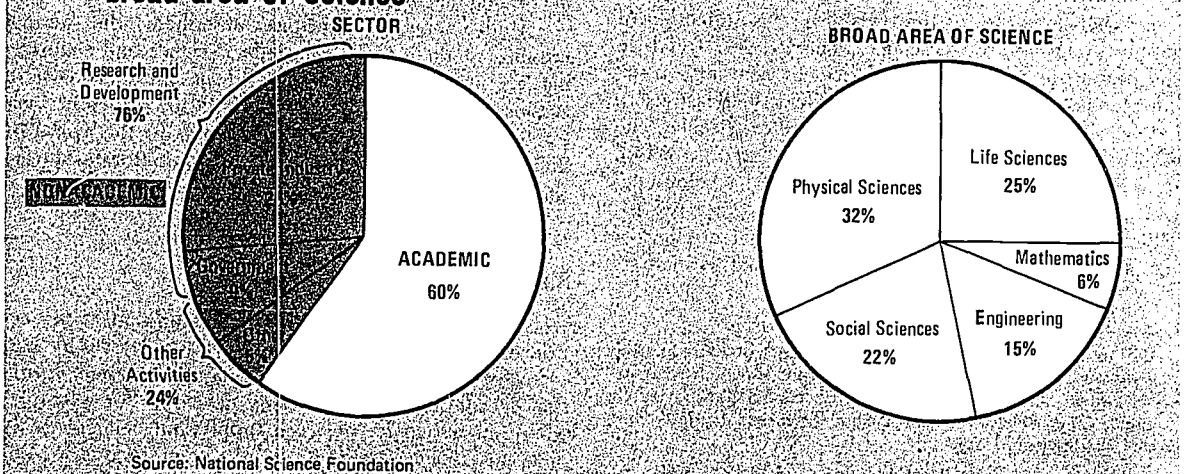
The base point for the supply and utilization projection is January 1969. It is estimated that as of that date, the number of doctorate-level scientists and engineers employed in various activities in the United States was approximately 158,000. This estimate was calculated from the number of doctorates earned in the years 1920 through 1969 from U.S. institutions, plus doctorates secured abroad by Americans or foreign nationals now employed in the United States. Subtracted from this were allowances for attrition caused by death or retirement, an allowance for those persons, almost entirely women, not undertaking a career in science or engineering, and for those foreign nationals who earned doctorates in the United States, but who subsequently left the country (appendix A).

Nearly three-fifths, or 94,000, of the 158,000 doctoral scientists and engineers in 1969 were employed by universities and colleges; another one quarter, or 41,000, were in private industry; and the remainder were employed by government agencies and other (primarily nonprofit) organizations—15,000 and 8,000, respectively (chart 4).

For the purposes of this study, another broad distinction is made—between doctorates in the nonacademic sector who are engaged in research and development, 49,000, and those engaged in other activities, 15,000. The five broad areas of science considered are the physical sciences, 51,000; the life sciences, 39,000; mathematics, 10,000; engineering, 23,000, and the social sciences (excluding history), 35,000 (chart 4).

Chart 4

1969 utilization of science and engineering doctorates, by sector and broad area of science



Source: National Science Foundation

Projected Supply

Changes in Methods and Assumptions

The new supply projections represent an important change from the methodology and assumptions used in the 1969 study (NSF 69-37) to estimate the number of science and engineering doctorates likely to be awarded during the next decade. The earlier projections were based on an extrapolation by the U.S. Office of Education (OE) of trends since 1958 in graduate enrollments. This included a period of rapid increase in the proportion of the student-age population pursuing all phases of higher education. Recent experience seems to indicate that these earlier trends may not be applicable to conditions of the 70's. Federal R&D funding has leveled and graduate enrollment is rising much less steeply than previously. With full realization of the potential pitfalls inherent in projections based on any short-term trend,[6] new supply projections were developed based on 1964-69 trends with adjustments made to reflect recent deviations from earlier trends. This estimate, of course, relies on OE projections of total bachelor's degrees likely to be awarded, which depend more on demographic influences and less on changing propensities to pursue higher education.[7]

Bachelor's Degrees

Another feature of the revision is the projection of supply by broad area of science. The 1964-69 trends in the proportion of bachelor's degrees in each area of science to the total were adjusted to reflect the relationship between earlier trends and recent actual experience. The adjusted trend lines were then extrapolated to 1980. Chart 5, section A shows the number of bachelor's degrees awarded in 1969, and the number projected for 1980 for each area of science. The annual number of social science bachelor's degrees is projected to increase by almost two and a half times during the decade; for life sciences and mathematics the annual projected production rate is somewhat less than 50 percent of the 1969 annual rate, and in the physical sciences and engineering the projections result in no increases.

Doctorates

Once the area of science distribution for bachelor's degrees awarded throughout the decade was projected, the next step was to translate, area by area, bachelor's degrees to a projection of doctorates awarded. This consisted of projecting lag relationships between bachelor's degrees, first-year enrollment for advanced degrees, total enrollment for advanced degrees, and doctorates awarded, on the basis of trends observed for the 1964-69 period, but again adjusted to reflect the relationship between earlier trends and recent actual data (appendix B). The successive results of this process are illustrated in chart 5. As was the case with bachelor's degrees, the annual rate of doctorates awarded in the social sciences is projected to more than double during the decade; the physical sciences projection shows only a slight annual increase in production rate; mathematics, the life sciences, and engineering projections show intermediate increases in annual doctorate production in order of decreasing magnitudes.

Under the assumptions described, the annual number of doctorates awarded in science and engineering are projected to increase from about 16,000 in academic year 1968-69 to 26,000 in academic year 1979-80. This projection would result in the award of 235,000 total science and engineering doctorates during the 1969-80 period.

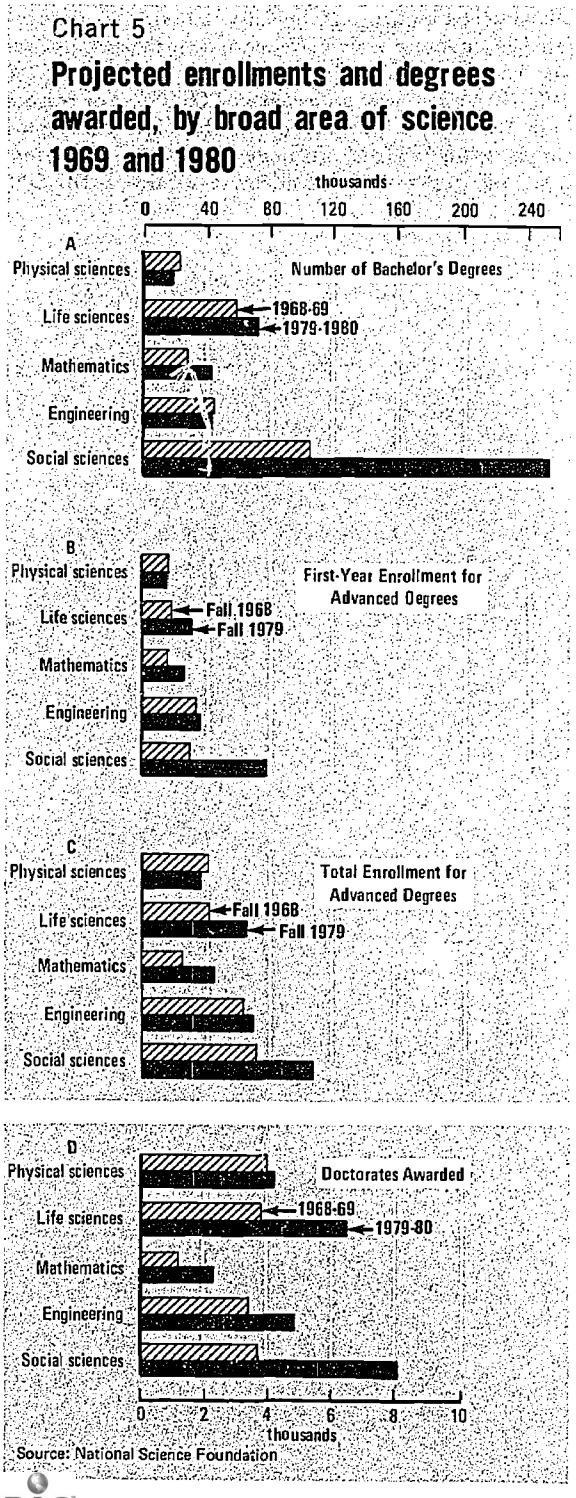
Shifts Among Areas of Science

The supply estimate described represents a projection of recent trends in higher education degrees by area of science. However, forces are likely to intervene during the decade as new conditions develop. For example, where an imbalance between supply and demand exists or seems to be developing in one or more areas of science, one response could be a shift in field distribution as a result of changes in career choice. In this connec-

[6] For a useful exploration of the dangers of extrapolating degrees awarded in the social sciences from short-term trends, see National Academy of Sciences, Social Sciences Research Council, *The Behavioral and Social Sciences: Outlook and Needs*. Washington, 1969.

[7] Department of Health, Education, and Welfare, Office of Education, *Projections of Education Statistics to 1979-80*, in press.

tion, it should be pointed out that the field shifts would have to occur fairly early in the decade to affect the supply projection significantly. This is a consequence of the 7- to 8-year average period required to complete graduate work in science. Other possible factors might include: changes in student attitudes toward science in general or toward a particular field; further changes in the overall job market for doctoral scientists, resulting in reductions in applications for graduate school; changes in policies of graduate schools on the acceptance of applicants; financial difficulties, including shortages of research funds necessary to train doctorates; or reduced support for graduate students (e.g., fellowships and traineeships). The effect of factors of this kind are difficult to predict, but since most of them would tend to reduce the number of doctorates awarded, it was decided to let the calculated supply figures represent the high end of the supply range and assume a 10-percent lower projection for the low end of the range.



Migration of Doctorates To and From the United States

The existing stock of doctorates in the United States includes some persons who earned their degrees from foreign universities. Over the past several decades a considerable number of trained scientists and engineers have entered this country as immigrants, and many of these have possessed doctorates at the time of immigration. In addition, a number of U.S. citizens have received doctorate training in foreign institutions. The immigration of doctoral scientists will be subject to some of the same forces described above as affecting domestic doctorate production, with the additional uncertainty of possible shifts in opportunity abroad. The latest data on immigration do not yet indicate a definite shift in past trends in the influx of foreign scientists. However, if present conditions persist, this source of doctorates could decline, resulting in a decrease in supply.

On the other hand, not all persons earning doctorates at U.S. institutions remain in the United States. In recent years, the proportion of persons receiving the doctorate who were not U.S. citizens has been about 15 percent for all fields, according to the survey of earned doctorates conducted annually by the National Academy of Sciences-National Research Council.[8] In some science and engineering fields the ratio has been considerably higher, e.g., engineering (25 percent), and agriculture and forestry (34 percent), and in some fields lower, e.g., psychology (5 percent) and botany and zoology (12 percent). Some of these non-U.S. citizens elect to leave the United States and others remain to pursue their careers. Information from the NAS-NRC Doctorate Survey indicates that about one-third of the noncitizens expect to be employed outside the United

[8] National Academy of Sciences—National Research Council, *Doctorate Recipients From United States Universities, 1958-66* and *Summary Report for 1967, 1968, 1969, and 1970* (Washington, D.C.).

States and a small percentage of U.S. citizens plan likewise. Between 5 percent and 10 percent of new science and engineering doctorates plan employment in a foreign country upon receipt of the degree. Some of the noncitizens who remain in the United States may eventually return abroad for employment, and some of the U.S. citizens abroad may return to the United States. It has been estimated for this report that approximately 10 percent of the total doctorates awarded each year should not be considered as additions to the stock of doctorates in the United States. This proportion has been assumed for all years. The same kind of supply-demand pressures that affect immigration could also lead to an increase in emigration. Anecdotal evidence indicates this trend may already have started a decrease in supply.

After adjustments for migration (a net loss of 19,000 doctorates during 1969-80), plus a very small adjustment for attrition (appendix B, item II D), the calulated net number of new science and engineering doctorates becoming available to the U.S. economy during the 1969-80 period was projected at 208,000. For reasons indicated above, this represents the high incremental supply estimate. The low supply estimate for the period, based on 10 percent fewer doctorate awards, is 187,200.

Projected Utilization

The low value for the revised 1980 utilization projection of science and engineering doctorates does not differ appreciably from the low value in the previous (1969) study.[9] However, the revised high estimate is significantly below that projected previously. There are two major reasons for the latter. The high R&D funding estimate upon which the earlier projection was based, 4.4 percent of the GNP in 1980, is no longer considered probable. Secondly, the projections of graduate enrollment in the sciences have been revised downward considerably, thus reducing the graduate faculty utilization projection. The following discussion involves the various factors upon which the revised utilization projections are based. These include growth in R&D funding, increase in college and university enrollment, absorption of doctorates into new and vacated positions, and the broadening scope of utilization of doctorates.

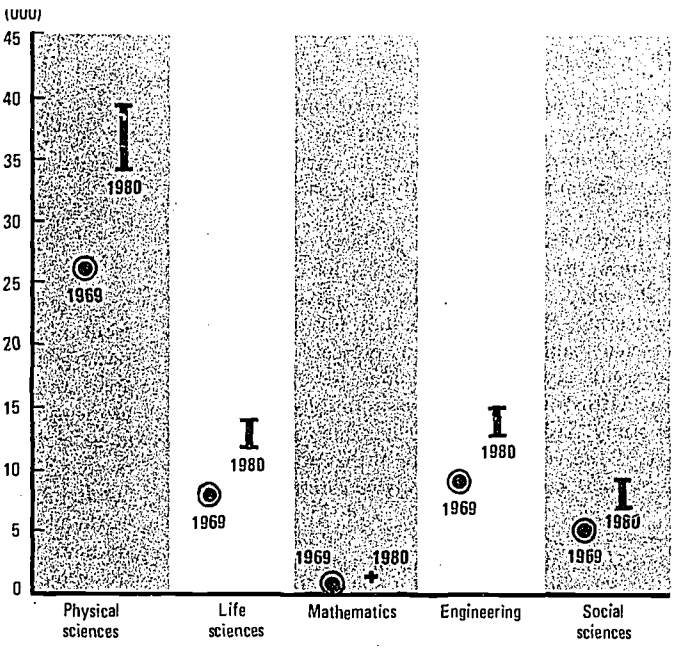
[9]National Science Foundation, *Science and Engineering Doctorate Supply and Utilization, 1968-80, op. cit.*

Growth in Nonacademic R&D Funding

Federal R&D funding, 57 percent in 1969, is a major portion of the R&D funding of the nonacademic sectors—private industry, government, and nonprofit organizations. Nonacademic research and development utilized some 31 percent of doctoral scientists and engineers in 1969. In the 13 years preceding 1966, Federal funding of nonacademic research and development had been increasing at about 13 percent a year. The reversal of this trend, which started in 1966, continued through fiscal year 1971, and the proposed 1972 increase does not return to the high rates of the past. Federal expenditures for nonacademic research and development in-

Chart 6

Nonacademic science and engineering doctorates engaged in R&D, by broad area of science, 1969 and 1980.



Note: Vertical bars indicate range between high and low projected values of supply and utilization.

Source: National Science Foundation

creased slightly from $13.0 billion in 1967 to $13.4 billion in 1969. The present study assumes that total R&D funding will be between 2.7 percent of the GNP, the estimated 1970 ratio and the lowest in the past decade, and 3.0 percent of the GNP, the highest it has ever attained.

To translate the above ratios into dollars, and ultimately R&D doctorates in the nonacademic sector, a 1968-80 BLS study[10] was used which projects GNP growth at 4.3 percent per year (appendix C). The evaluation of this projection is beyond the scope of the present study. However, it must be pointed out that between 1968 and 1970 the GNP grew only a net 2.2 percent in real terms, with actually a decline in real terms in 1970 for the first time since 1958. In a relatively long-range projection, cyclic conditions existing at the time the projection is made should not be overemphasized. Nevertheless, it is important to keep in mind that the projected 1980 utilization of doctorates in nonacademic research and development will be highly dependent upon economic conditions prevalent throughout the 70's.

Finally, the most likely distribution by broad area of science for 1980 nonacademic R&D scientists and engineers depends on numerous government and private decisions concerning R&D programs to be financed. Past trends in the proportion of total scientists and engineers by broad area engaged in research and development were projected to 1980. These projected ratios were applied to the BLS estimates of total scientists and engineers by field for 1980.[11] The result is a projection of 1980 R&D scientists and engineers by broad area, as shown in chart 6.

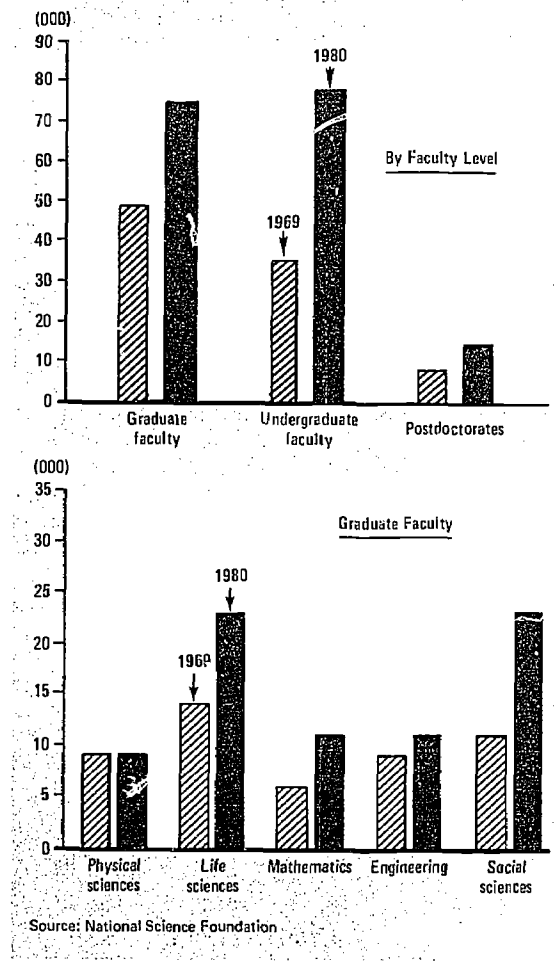
Growth in College and University Faculty

The largest proportion of science and engineering doctorates—some 60 percent in 1969—are employed by colleges and universities, and student enrollment is an important determinant of how this group will grow over the decade.

The propensities to pursue graduate work, ever increasing during the early and mid-60's, have now leveled out considerably, particularly in the physical sciences and engineering. Overall, enrollment for advanced degrees in science and engineering is projected to increase by 43 percent, compared to an increase of 99 percent under the Office of Education assumptions used in the previous study. This change is responsible for a considerable part of the reduction of the utilization of doctorates for graduate faculty in this revised estimate.

Chart 7

Academic science and engineering doctorates, by faculty level and broad area of science, 1969 and 1980



The effect of marked differences in graduate enrollment by broad area of science is reflected in chart 7. Because an increasing proportion of total bachelor's degrees are in social science, and because of an increasing propensity to attend graduate school, graduate enrollment in this area of science is projected to grow sharply, resulting in almost doubling the social science graduate faculty during the projection period. Life sciences and mathematics projections show smaller increases, while graduate faculty in the physical sciences and engineering are projected to remain relatively stationary. Unlike most graduate science faculty, undergraduate science faculty also teach nonscience students, so that faculty growth depends on enrollments in all fields. The distribution by broad area of science among undergraduate

[10] Department of Labor, Bureau of Labor Statistics, *Patterns of U.S. Economic Growth*, BLS Bulletin 1672 (Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, 1970.)

[11] Department of Labor, Bureau of Labor Statistics, *College Educated Workers, 1968-80, op. cit.*

science faculty is assumed, for the purposes of this study, to remain constant with time.

In addition to enrollment growth, projected increases in academic R&D funding will also influence faculty growth. This factor was implicity considered in projecting graduate faculty utilized in 1980, and was the explicit determinant of the number of postdoctorates in academic institutions.

Doctorate Absorption Into New Positions

Part of the projected growth in the utilization of doctorates at colleges and universities illustrated in chart 8 is due to an assumed increase in doctorates as a proportion of total faculty by 1980. As of January 1969, the doctoral-to-total-faculty ratio was estimated to be 81 percent for graduate faculty and 36 percent for undergraduate faculty. While empirical data concerning recent trends are less than adequate, the best available evidence is that this ratio of doctorates to total faculty for all levels has been increasing about 0.8 of a percentage point a year over the past few years.[12] This estimate for annual change in the overall ratio was disaggregated by assigning about 1 percentage point change every 2 years at the graduate level, and 1 percentage point every year at the undergraduate level throughout the 1969-80 period. The rationale for this procedure is that there is more room for the ratio to grow at the latter than at the former level. These projected increases in the doctoral-to-total-faculty ratio result in 95 percent of the new graduate faculty positions being filled by doctorates and 62 percent of the new undergraduate faculty positions being so filled.

In the case of nonacademic R&D positions, it has been assumed that doctorate absorption rates will be alternatively 10 percent and 20 percent higher than the doctorate-to-total-scientists ratio existing in the particular category in 1969. This assumption is based on the conviction that in the past the utilization of doctorates was restricted by short supply.

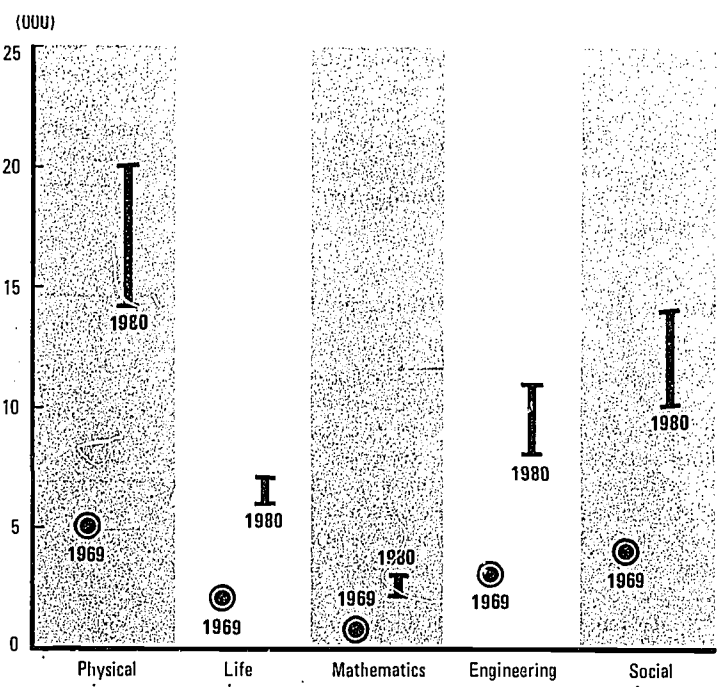
Broadening the Scope of the Utilization of Doctorates

Under the present methodology, doctorates utilized in the nonacademic sector in activities other than research and development (e.g., administrators, directors of scientific laboratories in industry and government, scientists and engineers engaged in the utilization of R&D

[12] National Science Foundation, *Resources for Scientific Activities at Universities and Colleges, 1969* (NSF 70-16) (Washington, D.C. 20402: Supt. of Documents, U.S. Government Printing Office, 1970.)

Chart 8

Nonacademic science and engineering doctorates in activities other than R&D, by broad area of science, 1969 and 1980.



Note: Vertical bars indicate range between high and low projected values of supply and utilization.

Source: National Science Foundation

results, program managers in government, consultants) are projected as a separate group. The relative size of this group is projected to grow at least at the rate prevailing during the 60's—4.0 percent annually for all fields combined—a period during which science doctorates were in much shorter supply than at present. Using this rate, the proportion of nonacademic doctorates in "other activities" would increase from 10 percent in 1969 to 15 percent of the total in 1980. The low utilization estimate for 1980 is based on this projection of the past growth rate trend. However, because there is reason to believe that the past utilization of doctorates for nonacademic activities other than research and development has been restricted due to a short supply of doctorates, an alternative assumption was also made: doctorates in the nonacademic sector in activities other than research and development will be 25 percent higher—19 percent, as against 15 percent, of the total—in 1980 than would have been the case under the historic trend. This latter assumption is the basis of the high utilization projection. Under both assumptions, separate calculations were made by broad areas of science according to past trends in each area (chart 8).[13]

Doctorate utilization is also projected to increase in the academic sector. Relatively more doctorate faculty are projected to be teaching undergraduates in 1980 than in 1969. In 1969, 40 percent of the academic doctorates were engaged in teaching undergraduates; for those entering academic employment during the 1969-80 period, however, some 54 percent (high projection) are projected to be utilized in teaching undergraduates.

Finally, when nonacademic doctorates engaged in activities other than research and development and teachers of undergraduates are considered as a single group, some 53 percent (high projection) of the doctorates entering employment during the 1969-80 period are expected to belong to this combined group, as compared to 33 percent in 1969.

Attrition Due to Death or Retirement

Some new doctorates will replace scientists and engineers who die or retire during the projection period. The revised estimates of attrition due to death or retirement do not differ very much overall from those of the previous study (NSF 69-37). However, considerably more attention was devoted this time to differential rates of attrition by broad area of science, sector, and degree level (appendix C). Doctorate absorption into the vacated faculty and nonacademic R&D positions was assumed to be at the same rates indicated above as applying to new positions due to growth. Doctorates engaged in nonacademic activities other than research and development who vacate their positions are assumed to be replaced by other doctorates.

Summary of Changes in Pattern of Utilization

The sectoral and functional shifts in science and engineering doctorate utilization over the projection period are summarized below. The figures in the last three columns are ranges: The first figure is based on the low utilization estimate and the second on the high utilization estimate.

	Percentage of doctorates			
	1969	*New entries 1969 to 1980*	*1980*	*Change 1980-1969*
Total	100	100	100	0
Academic	60	60 to 51	60 to 55	0 to −5
Nonacademic				
R&D	30	20 to 23	25 to 26	−5 to −4
Other	10	20 to 26	15 to 19	+5 to +9

For the lower 1980 utilization estimate, the projected shift is from research and development to non-R&D activities within the nonacademic sector. For the higher estimate, this shift is even more pronounced, and, in addition, there is a significant projected shift from academic to nonacademic utilization.

The shifts in utilization by broad area of science are also summarized. The figures in the last three columns are ranges: The first figure is based on the low utilization estimate and the second on the high utilization estimate.

	Percentage of doctorates			
	1969	*New entries 1969 to 1980*	*1980*	*Change 1980-1969*
Total	100	100	100	0
Physical sciences ...	33	24 to 27	28 to 30	−5 to −3
Life sciences	25	27 to 25	26 to 25	+1 to 0
Mathematics	6	9 to 8	8 to 7	+2 to +1
Engineering	14	13 to 14	13 to 14	−1 to 0
Social sciences	22	27 to 26	25 to 24	+3 to +2

The tendency for the physical sciences to decline and the social sciences to gain as a proportion of total utilization should be viewed as occurring chiefly within the academic sector. For the higher 1980 estimate, this tendency is damped by the relatively faster growth in the nonacademic sector, where the physical sciences are traditionally emphasized.

Though the assumption of an increase over the projection period in the doctorate-to-total-scientist ratio

[13] In this study the utilization of doctorates in nonacademic activities other than research and development is considered to be principally a function of demand factors. This is not to deny that broadened utilization of science and engineering doctorates also is a safety valve tending to bring employment into balance with supply.

is considered the most reasonable one, some readers may wish to consider projections based upon an assumption that no such increase occurs. This so called "no enrichment" result is shown in table 2. It is 13 percent below the low utilization projection and 21 percent below the high utilization projection shown in table 1. The doctorate utilization result portrayed in table 2 should not be construed as an alternative to those results indicated in table 1. It is displayed as an extreme low utilization limit.

Table 2.—SCIENCE AND ENGINEERING DOCTORATES, BY TYPE OF UTILIZATION AND BROAD AREA OF SCIENCE, 1980, ASSUMING "NO ENRICHMENT"

[In thousands]

Type of utilization	*Total*	*Physical sciences*	*Life sciences*	*Mathematics*	*Engineering*	*Social sciences*
Total doctorate utilization	235.1	69.0	60.3	17.2	32.9	55.6
Academic	136.4	24.0	44.0	14.6	13.7	40.0
Nonacademic R&D	63.9	32.3	11.5	1.0	12.1	7.0
Nonacademic other	34.8	12.7	4.8	1.6	7.1	8.6

Appendixes

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Appendix A

Development of January 1969 Estimate of Doctoral and Total Scientists by Sector, Broad Area of Science, and Activity

I. Total Doctoral Scientists and Engineers

A. The January 1968 estimate of doctoral scientists and engineers, 147,000 (NSF 69-37) was reduced by 1.8 percent to allow for death or retirement during the year.

B. Using National Research Council data *(Summary Report, 1968, Doctorate Recipients From United States Universities;* similar report for 1969), 66.2 percent of 1967-68 doctorates awarded in science and engineering, 9,708 (estimated proportion for second half of year), and 33.8 percent of 1968-69 awards, 5,522 (first half of year), were assumed to be additions to supply. This figure was adjusted by subtracting 10 percent, or 1,523, for emigration, and adding 250 for immigration. The result, 158,000, is shown by broad area of science in line 1, table A-3.

II. Academic Sector

A. Doctoral and total academic scientists by broad area of science were derived from the 1969 NSF survey *(Resources for Scientific Activities at Universities and Colleges, 1969,* NSF 70-16) under the assumption that one-third of the part-time persons should be considered as a full-time equivalent attached to the academic sector. Persons in life sciences with medical degrees were excluded for the purposes of this study. The results for total academic scientists are shown on line 1, table A-1, and for doctorates on line 2, table A-3.

B. Graduate faculty (all degree levels) by broad area of science are derived from unpublished departmental data collected in connection with the NSF graduate traineeship program for academic year 1968-69. Ratios of graduate students, as shown on data sheets from 2,736 doctoral science departments, to faculty by field were calculated. The faculty figure used was the sum of full-time graduate faculty, nonteaching faculty, and one-third of the part-time graduate faculty. The ratios obtained were then applied to the full-time equivalent of enrollments for advanced degrees by broad area of science (Office of Education data) to arrive at the estimates of graduate faculty. The results are shown on line 2, table A-1.

C. Based again on unpublished data concerning the traineeship program, plus an examination of graduate study catalogs of a number of universities, doctoral faculty at the graduate level was estimated to be 85 percent of total graduate faculty in all broad areas of science. This was true except in engineering where there was an insufficient number of doctorates in the academic sector to allow this proportion. The results are shown on line 3, table A-3.

D. Postdoctorates by broad area of science:

1. Counts for the physical sciences, mathematics, and engineering are from the NSF traineeship program data sheets for the academic year 1968-69.
2. Counts for life and social sciences are from National Research Council tabulations of postdoctorates at U.S. host institutions in Spring 1967 *(The Invisible University, 1969).* Based on the estimates of the authors of the NRC report, the social science figure is adjusted for an estimated 80-percent response rate; the life science figure is adjusted for an estimated 80-percent response rate in biosciences and a 65-percent response rate in basic medical sciences; it was assumed that one-third of those in basic medical sciences were M.D.'s and this proportion was excluded. The figures are increased by 13 percent to update

to January 1969. NSF data indicate a 6.5-percent increase in postdoctorates between 1968 and 1969 *(Impact of Changes in Federal Science Funding Patterns on Academic Institutions, 1968-70,* 1970). The results for each broad area of science are shown in line 5, table A-3.

E. **Undergraduate faculty:** This is the residual after subtracting B through D from A above. The results for total scientists are shown in line 3, table A-1, and for doctorates in line 4, table A-3.

III. Nonacademic Sector

A. BLS estimates of R&D natural scientists and engineers by broad area of science for private industry in 1969 were used.

B. R&D to total scientists and engineers ratios by broad area of science from the 1969 NSF survey *(Scientific, Technical, and Health Personnel in the Federal Government, 1969,* NSF 70-44) were applied to the 1969 BLS estimate of scientists and engineers in the Federal sector to obtain R&D natural scientists and engineers by broad area of science.

C. The 1966 BLS ratio of R&D to total natural scientists and engineers in State government *(Employment of Scientists and Engineers in the United States, 1950-66,* NSF 68-30) was applied to the 1969 BLS estimate of natural scientists and engineers in this sector to obtain a count of R&D natural scientists and engineers. This count was distributed by broad area of science in proportion to R&D funding of natural sciences and engineering in 1968 *(Research and Development in State Government Agencies, Fiscal Years 1967 and 1968,* NSF 70-22).

D. The counts of R&D natural scientists and engineers by broad area of science for local government were obtained in a manner similar to those used for State government. The 1969 NSF data on the distribution of R&D funds in this sector were used *(R&D Activities of Local Governments).*

E. R&D to total natural scientists and engineers ratios by broad area of science for the nonprofit sectors are from the NSF survey *(Resources for Scientific Activities of Independent Nonprofit Institutions, 1970,* to be published). These are applied to the appropriate 1969 BLS counts of natural scientists and engineers to obtain R&D natural scientists by broad area of science for this sector. Counts of R&D scientists by area of science employed in Federally Funded Research and Development Centers administered by universities were obtained from an NSF survey *(Resources for Scientific Activities at Universities and Colleges, 1969,* NSF 70-16).

F. The count of nonacademic social scientists is obtained by subtracting the count of academic social scientists, already determined from the universities and colleges survey, from the approximation of 100,000 social scientists in all sectors. Data from the 1968 National Register were used to determine the proportion of this count engaged in R&D—36 percent. The resulting counts of nonacademic R&D scientists by broad area of science (A—F above) are shown in table A-2.

G. Nonacademic doctoral scientists and engineers are derived by subtracting the estimate for academic doctorates (II-A, preceding) from the January 1969 estimate for all science and engineering doctorates (I, preceding). Nonacademic doctorates are distributed by sector in the same proportions as in the January 1968 base (NSF 69-37) and within sector by broad area of science and activity in proportions compatible with the sectoral, science area, and activity distributions of NSF 69-37. The results are shown in lines 7 through 18, table A-3.

Table A-1.—UTILIZATION OF SCIENTISTS AND ENGINEERS IN COLLEGES AND UNIVERSITIES, BY FACULTY LEVEL AND BROAD AREA OF SCIENCE, JANUARY 1969

[In thousands]

Faculty level	*Total*	*Physical sciences*	*Life sciences*	*Mathematics*	*Engineering*	*Social sciences*
(1) Total academic scientists and engineers	173.6	31.4	53.3	19.9	22.9	46.1
(2) Graduate faculty[a]	59.8	10.1	16.1	6.9	13.4	13.3
(3) Undergraduate faculty	105.6	17.7	34.0	12.8	8.8	32.4
(4) Postdoctorates	8.2	3.6	3.2	.2	.7	.4

[a]Graduate faculty are defined as all individuals of academic rank of instructor or above who are significantly involved in the academic graduate program; i.e., teaching one or more graduate courses or seminars and/or directing research of one or more graduate students. Also included under graduate faculty for purposes of this study are nonteaching or research faculty.

Table A-2.—UTILIZATION OF NONACADEMIC R&D SCIENTISTS AND ENGINEERS,[a] BY BROAD AREA OF SCIENCE, JANUARY 1969

[In thousands]

	Total	*Physical sciences*	*Life sciences*	*Mathematics*	*Engineering*	*Social sciences*
Nonacademic R&D scientists and engineers	504.9	103.1	29.2	21.6	331.6	19.4

[a]Includes military scientists and engineers engaged in research and development and Federally Funded Research and Development Centers administered by colleges and universities.

Table A-3.—DOCTORATE SCIENTISTS AND ENGINEERS, BY TYPE OF UTILIZATION AND BROAD AREA OF SCIENCE, JANUARY 1969

[In thousands]

	Type of utilization	Total	Physical sciences	Life sciences	Mathematics	Engineering	Social sciences
(1)	Total doctorates	158.0	51.4	39.2	9.7	22.7	35.0
(2)	Academic	94.3	20.7	29.2	8.1	10.8	25.5
(3)	Graduate faculty[a]	48.5	8.6	13.7	5.9	9.0	11.3
(4)	Undergraduate faculty	37.7	8.5	12.3	2.0	1.1	13.8
(5)	Postdoctorates	8.2	3.6	3.2	.2	.7	.4
(6)	Nonacademic	63.7	30.7	10.0	1.6	11.9	9.5
(7)	R&D	48.6	25.5	7.8	.8	9.1	5.4
(8)	Other	15.1	5.3	2.3	.7	2.7	4.0
(9)	Private industry	41.2	24.4	3.4	1.1	9.7	2.7
(10)	R&D	32.3	20.4	2.8	.5	7.5	1.1
(11)	Other	8.9	4.0	.6	.5	2.1	1.5
(12)	Government[b]	15.0	3.7	5.3	.3	1.2	4.5
(13)	R&D	9.6	2.7	3.8	.1	.6	2.3
(14)	Other	5.4	1.1	1.5	.2	.5	2.1
(15)	Nonprofit and other[c]	7.5	2.7	1.4	.2	1.0	2.3
(16)	R&D	6.8	2.4	1.3	.2	.8	2.0
(17)	Other	.6	.2	.1	0	.2	.2

[a]Graduate faculty are defined as all individuals of academic rank of instructor or above who are significantly involved in the academic graduate program; i.e., teaching one or more graduate courses or seminars and/or directing research of one or more graduate students. Also included under graduate faculty for purposes of this study are nonteaching or research faculty.

[b]Includes military scientists and engineers holding doctorates.

[c]Includes Federally Funded Research and Development Centers administered by universities and colleges.

Appendix B

Supply Projections—Methodology and Results

I. Development of Projections of Doctorates Awarded by Broad Area of Science and Enrollment for Advanced Degrees by Broad Area of Science, 1969-80.

A. The Office of Education projection to 1979-80 of total bachelor's degrees awarded, which is closely connected to demographic data, was accepted as the starting point of this projection.

B. In order to translate total bachelor's degrees during the projection period to doctorates awarded by broad area of science, it was necessary to project each of the following parameters for each area of science:

1. Bachelor's degrees in the science area as a percent of total bachelor's degrees.
2. First-year enrollment for advanced degrees in the area as a percent of bachelor's degrees in the previous year.
3. Total enrollment for advanced degrees in the area as a percent of first-year enrollment for advanced degrees in the previous year.
4. Doctorates awarded as a percent of enrollments for advanced degrees 3 years earlier.

C. Using actual data for the period 1964 through 1969 for degrees and fall 1964 through fall 1969 for enrollment, regression lines were calculated for each of the 24 parameters described above—four steps for each of five science and one nonscience area—as possible projections of the 1969-80 period, but subject to the following adjustment.

D. Using actual data for the period 1961 through 1966 for degrees and fall 1961 through fall 1966 for enrollment, a second set of regression lines was applied as a retrospective test of fit to actual 1969 data. It was then determined which adjustment of slopes would best project the actual value of the respective parameter in subsequent years.

E. The adjustments developed in (D) were then applied to the slopes developed in (C). In the social sciences, the actual increase in enrollment for advanced degrees has been very stable over the last 6 years, increasing at about 5,000 per year. This annual increase was projected through the 1969-80 period.

F. The results for doctorates awarded by broad area of science are shown in table B-1, and for enrollment for advanced degrees by area of science (a byproduct) in table B-2.

II. Development of Net Doctorates Added to Supply, 1969-80

A. The number of science and engineering doctorates projected to be awarded by broad area of science for 1969-80 (described in (I) above) was totaled and adjusted as follows: Since the period chosen for analysis extends from January 1969 to January 1980, degrees awarded prior to January 1, 1969 and subsequent to January 1, 1980 should be excluded. Data available from the National Research Council indicate that the proportion of doctorates awarded between July 1 and December 31 has been rising steadily, reaching nearly 35 percent in 1967-68. It was assumed that this proportion would reach 40 percent by 1979-80. Thus, only 35 percent of the degrees awarded in academic year 1968-69 and 60 percent awarded in academic year 1979-80 were counted in the 1969-80 increment. The results are shown in line 1, table B-3.

B. Allowance for immigration. It is estimated that, as of 1968, the number of doctorates who earned their degrees outside the United States was about 11,000. The National Register in 1968 provides a minimum count of 6,500. This minimum count was increased to allow for undercoverage of scientists and noncoverage of engineers. It is estimated for this study that

4,600 doctorates will be added to the total national stock from institutions outside the United States between 1969-80. The distribution of these by area of science is shown in line 2, table B-3.

C. Allowance for emigration. The estimates (line 4, table B-3) are based on National Research Council data on the proportion of persons receiving the doctorate who are not U.S. citizens *(Summary Report, 1969, Doctorate Recipients from United States Universities)* and the proportion who expect to be employed outside the United States. *(Doctorate Recipients from United States Universities, 1958-1966).* The estimate represents 10 percent of total doctorates awarded, except for engineering and the social sciences, for which the proportions are 17 percent and 3 percent, respectively. The distribution of these by area of science is shown in line 4, table B-3.

D. Allowance for attrition. The doctorates projected to be awarded between 1969-80 after adjustment for emigration (C. above) were allocated by sex on the basis of the latest National Research Council data. It was assumed that 1 percent of the male and 25 percent of the female doctorates awarded during the projection period would be lost because of death, retirement, or withdrawal from the labor force. For males, this represents only the relatively few deaths and retirements expected in so young a group of individuals, based on U.S. Department of Labor separation rates, by age group. For women, allowance was made for withdrawals from the labor force before retirement age. The proportion selected is based on counts of the number of women who received doctorates between 1920 and 1967 (NRC data) and the number of female doctorates who were indicated in the 1968 National Register as being presently engaged in scientific work.

Table B-1.—DOCTORATES AWARDED BY BROAD AREA OF SCIENCE, 1960-80

[In thousands]

Year	All fields		Total sciences		Physical sciences		Life sciences		Mathematics		Engineering		Social sciences		Total non-science	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
1960-61	10.0	100.0	6.54	61.7	2.00	18.9	1.65	15.6	.34	3.2	.94	8.9	1.61	15.2	4.04	38.1
1961-62	11.6		7.25		2.12		1.80		.40		1.21		1.72		4.37	
1962-63	12.8		8.06		2.38		1.91		.49		1.38		1.90		4.77	
1963-64	14.5		9.03		2.46		2.18		.60		1.69		2.10		5.47	
1964-65	16.5	100.0	10.25	62.1	2.83	17.2	2.47	15.0	.69	4.2	2.12	12.8	2.14	13.0	6.22	37.7
1965-66	18.2		11.30		3.05		2.70		.80		2.30		2.45		6.94	
1966-67	20.6		12.75		3.46		2.90		.87		2.61		2.91		7.86	
1967-68	23.1		14.13		3.59		3.45		.98		2.93		3.18		8.96	
1968-69	26.2		15.84		3.86		3.78		1.16		3.38		3.66		10.40	
1969-70	28.4	100.0	16.88	59.4	4.03	14.2	4.03	14.2	1.28	4.6	3.48	12.3	4.06	14.3	11.54	40.6
1970-71	31.4		18.35		4.28		4.36		1.39		3.79		4.53		13.09	
1971-72	33.7		19.23		4.34		4.55		1.48		3.92		4.94		14.49	
1972-73	35.9		19.98		4.23		4.82		1.62		4.06		5.25		15.90	
1973-74	38.4		21.39		4.24		5.31		1.81		4.38		5.65		16.94	
1974-75	39.1	100.0	21.95	56.1	4.19	10.7	5.42	13.9	1.85	4.7	4.44	11.4	6.05	15.5	17.12	43.9
1975-76	40.4		22.78		4.21		5.61		1.94		4.56		6.46		17.56	
1976-77	41.4		23.47		4.19		5.79		2.00		4.63		6.86		17.86	
1977-78	42.6		24.23		4.19		6.02		2.09		4.67		7.26		18.42	
1978-79	43.9		25.00		4.19		6.23		2.17		4.74		7.67		18.87	
1979-80	45.2	100.0	25.83	57.1	4.19	9.3	6.47	14.3	2.27	5.0	4.84	10.7	8.06	17.8	19.42	43.0

Note: 1960-61 to 1968-69, actual OE data; 1969-70 to 1979-80, estimated by NSF. Percents may not add to 100 because of rounding.

Table B-2.—ENROLLMENT FOR ADVANCED DEGREES BY BROAD AREA OF SCIENCE, 1960-80

[In thousands]

Fall of year	All fields		Total sciences		Physical sciences		Life sciences		Mathematics		Engineering		Social sciences		Total non-science	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
1960	314.2	100.0	120.6	38.4	25.7	8.1	19.7	6.3	11.8	3.8	36.6	11.7	26.8	8.5	193.7	61.6
1961	339.0		128.9		26.6		21.4		12.7		39.4		28.8		210.1	
1962	378.8		142.5		28.6		24.0		14.1		43.9		31.9		231.3	
1963	413.4		158.1		31.0		25.9		16.0		48.9		35.3		255.3	
1964	477.5		178.1		34.0		30.8		18.8		54.3		40.2		299.4	
1965	535.3	100.0	195.3	36.4	36.5	6.8	34.7	6.5	21.0	3.9	57.5	10.7	45.6	8.5	340.0	63.5
1966	583.0		207.1		38.0		37.0		23.2		58.3		50.6		375.9	
1967	649.7		224.5		40.4		40.0		25.1		62.6		56.4		424.2	
1968	703.7		234.6		40.9		41.7		26.8		63.7		61.5		469.1	
1969	756.9		243.7		39.9		44.2		29.2		65.0		65.4		513.2	
1970	805.7	100.0	261.1	32.4	40.0	5.0	48.7	6.0	32.8	4.1	69.2	8.6	70.4	8.7	544.6	67.6
1971	816.1		267.3		39.5		49.7		33.5		69.2		75.4		548.8	
1972	837.6		276.7		39.7		51.5		35.0		70.1		80.4		560.9	
1973	853.3		284.4		39.5		53.1		36.1		70.3		85.4		568.9	
1974	875.5		292.7		39.5		55.2		37.7		69.9		90.4		582.8	
1975	896.6	100.0	301.4	33.6	39.5	4.4	57.2	6.4	39.2	4.4	70.1	7.8	95.4	10.6	595.2	66.4
1976	921.8		311.0		39.5		59.4		41.0		70.7		100.4		610.8	
1977	943.1		319.7		39.3		61.7		42.7		70.5		105.4		623.5	
1978	962.9		328.0		38.8		63.8		44.5		70.5		110.4		634.9	
1979	978.9		334.9		37.8		65.8		46.0		69.9		115.4		644.0	
1980	995.3	100.0	341.7	34.3	36.7	3.7	67.7	6.8	47.7	4.8	69.2	7.0	120.4	12.1	653.6	65.7

Note: 1960-69, actual OE data; 1970-80, estimated by NSF. Percents may not add to 100 because of rounding.

Table B-3.—INCREMENTAL SUPPLY OF SCIENCE AND ENGINEERING DOCTORATES, BY BROAD AREA OF SCIENCE, 1969-80

[In thousands]

Supply factors	Total	Physcial sciences	Life sciences	Mathematics	Engineering	Social sciences
(1) Doctorates awarded, 1969-80	234.5	46.3	57.2	19.3	46.8	64.9
(2) Plus immigration	4.6	2.2	.3	.2	1.4	.5
(3) Subtotal	239.1	48.5	57.5	19.5	48.2	65.4
(4) Less emigration	−23.5	−4.9	−6.1	−2.0	−8.6	−1.9
(5) Less female attrition	−5.6	−.6	−1.8	−.2	—	−3.0
(6) Less male attrition	−2.0	−.4	−.4	−.2	−.4	−.6
Subtotal	−31.1	−5.9	−8.3	−2.4	−9.0	−5.5
(7) Supply, 1969-80	208.0	42.6	49.2	17.1	39.2	59.9

Appendix C

Utilization Projections—Methodology and Results

I. Incremental Academic Utilization of Doctorates Due to Growth, by Broad Area of Science, 1969-80.

A. Graduate faculty was projected to grow in proportion to enrollment for advanced degrees with each science area considered separately. (See table B-2). It was projected that 95 percent of the new positions due to growth would be filled by doctorates. The results are shown in line 3, table C-1.

B. Undergraduate faculty was projected to grow in proportion to undergraduate enrollment[14] (separate projections for 2- and 4-year institutions). No change in area of science mix was projected to occur over the 1969-80 period. It was projected that 62 percent of the new undergraudate faculty positions would be filled by doctorates. The results are shown in line 4, table C-1.

C. Postdoctorates were projected to increase in proportion to R&D funding in the academic sector. (See II-A later in this section concerning two projected R&D funding levels.) The area of science mix was projected not to change over the 1969-80 period. The results are shown in lines 5 and 6, table C-1.

II. Incremental Nonacademic R&D Utilization of Doctorates Due to Growth, By Broad Area of Science, 1969-80.

A. Projected R&D Expenditures. Two estimates of 1980 R&D expenditures were developed on (1) the relationship of research and development to Gross National Product (GNP) in 1970 (estimated 2.7 percent—lowest ratio in the last decade), and (2) the peak level of R&D to the GNP (3 percent—reached in 1964). The estimates of GNP are from the Bureau of Labor Statistics report, *Patterns of U.S. Economic Growth*. Projected 1980 R&D expenditures (in 1969 dollars) range between $40 and $45 billion. These are shown in table C-2.

Projections of Federal R&D support in each of the sectors of the economy in 1980—industry, universities, and other nonprofit organizations—were based on the 1969 ratio of Federal R&D to the GNP. Non-Federal support was developed on the basis of projecting trends for each sector. Industrial support of its own research and development, over one-third of the total 1969 R&D expenditures in the economy, was projected on the basis of an average of trend rates for the periods 1960-66 and 1966-69.

Federally supported research and development as a percentage of total research and development is projected to decrease from 57 percent in 1969 to 53 percent in 1980. In both estimates—2.7 and 3 percent of the GNP—Federal research and development in relation to total Federal budget outlays is projected to decline from the 1969 level of 8.1 percent to a low of 7.1 and a high of 7.9 percent.

Non-Federal support to universities and colleges, approximately 4 percent of total 1969 research and development in the economy, was based on the assumption that such growth would be related to increases in Federal support to such organizations. However, it was projected that the 1969 relationship of 59-percent Federal funding and 41-percent non-Federal would by 1980 be 55 percent and 45 percent, based upon past trends. Non-Federal estimate for nonprofit organizations, only 1 percent of total 1969 R&D spending, was based on the period 1964-69 since survey data are not available prior to 1964.

B. Development of 1980 estimate of nonacademic R&D cost per R&D natural scientist and engi-

[14] Department of Health, Education, and Welfare, Office of Education, *Projection of Education Statistics, op. cit.*

neer. Using the time series developed for NSF's *National Patterns of R&D Resources, 1953-71* (NSF 70-46), the annual average compound rate of increase in nonacademic R&D cost (in 1969 constant dollars) per nonacademic R&D scientist for the 1961-69 period was calculated. The 1969 nonacademic R&D cost per R&D natural scientist and engineer (demoninator from the natural scientist and engineer base described in appendix A, not *National Patterns* data) was then projected to 1980 by assigning a weight of two-thirds to the 1961-69 trend and a weight of one-third to zero growth (roughly the situation over the 1965-69 period).

C. The 1980 nonacademic R&D cost per nonacademic R&D natural scientist ratio (B above) was applied to the low and high 1980 projections of nonacademic R&D funds (A above) to determine the 1980 projection of nonacademic R&D natural scientists and engineers by sector.

D. Distribution by broad area of science of nonacademic R&D natural scientists and engineers. Available historic trend data on the relation between R&D and total natural scientists were examined to project 1980 ratios. The 1980 ratios of R&D to total scientists by area of science were then applied to a 1980 BLS projection for total nonacademic natural scientists and engineers; [illegible] done to determine nonacademic R&D natural scientists and engineers by area of science. The results were then normalized to the nonacademic R&D natural scientist and engineer total derived in C above.

E. Nonacademic R&D social scientists were assumed to increase in proportion to nonacademic R&D natural scientists and engineers.

F. The incremental nonacademic R&D utilization of scientists and engineers by area of science due to growth was obtained by subtracting the 1969 counts of nonacademic R&D scientists and engineers by area of science (table A-2) from the 1980 projections (B-E above).

G. It was assumed that new positions due to growth (F above) would be filled by doctorates at doctoral-to-total-scientist ratios 10 percent, or alternatively 20 percent, above the ratios existing in 1969. The resulting estimates for nonacademic doctorates engaged in research and development in 1980 are shown in table C-3, lines 1-4.

III. Incremental Nonacademic Utilization of Doctorates in Activities Other than R&D Due to Growth, By Broad Area of Science, 1969-80.

A. Based on 1960-68 National Register data, the following annual compound rates were projected for growth in the proportion that nonacademic doctorates in activities other than R&D, hereafter referred to as "nonacademic other," are to total doctorates: all science areas combined, 4.0 percent; physical sciences, 8.9 percent; life sciences, 6.1 percent; and mathematics, 5.7 percent. Since the Register does not cover engineering, and its coverage of social sciences other than psychology has been too recent to afford time trend data, the physical and life sciences rates assumed for these science areas were 8.9 and 6.1 percent, respectively.

B. These growth rates were applied to the 1969 estimate of "nonacademic other" doctorates as a proportion of the total (appendix A) to project 1980 proportions.

C. In addition, an alternative set of 1980 projected "nonacademic other" proportions 25 percent higher than described in B above was assumed. The equivalent growth rates were as follows: all science areas, 6.2 percent; the physical sciences, 11.1 percent; the life sciences, 8.3 percent; mathematics, 7.3 percent; engineering, 11.1 percent; and the social sciences, 8.3 percent.

D. The low (B) and high (C) 1980 "nonacademic other" proportions were translated to absolute numbers of doctorates as follows: The low "nonacademic other" proportions were used in conjunction with the low estimates for academic and nonacademic R&D doctorates, and the high "nonacademic other" proportions were used in conjunction with the high academic and nonacademic R&D estimates.

E. The 1980 low and high estimates for "nonacademic other" doctorates are translated to incremental utilization due to growth by subtracting the 1969 base figures from the results of D, preceding. The results are shown in lines 1 and 2, table C-4.

IV. Incremental Utilization of Doctorates Due to Death or Retirement, by Broad Area of Science, 1969-80.

A. Department of Labor death and retirement rates by age (tables of working life) were applied to the 1969 scientist and engineer base, assuming age distributions corresponding to those in the 1968 National Register, to estimate the number of positions vacated due to death or retirement. Separate age distributions and calculations were made by degree level (doctorate–nondoctorate), broad area of science, and sector (academic–nonacademic).

B. Replacement by doctorates of academic scientists and engineers lost to death or retirement. It was assumed that the positions vacated because of death and retirement would be filled by doctorates in the same proportions as assumed in (I) preceding, in connection with the filling of new positions due to growth. The results are shown in table C-5.

C. Replacement by doctorates of nonacademic R&D scientists and engineers lost to death or retirement. It was assumed that positions vacated by death or retirement would be filled by doctorates in the same proportions as assumed in (II) preceding. The results are shown in table C-6.

D. It was assumed that nonacademic doctorates engaged in activities other than R&D lost due to death or retirement would be replaced by doctorates. The results are shown in table C-7.

Table C-1.–INCREMENTAL ACADEMIC UTILIZATION OF DOCTORATES DUE TO GROWTH, BY BROAD AREA OF SCIENCE, 1969-80

[In thousands]

Faculty level	*Total*	*Physical sciences*	*Life sciences*	*Mathematics*	*Engineering*	*Social sciences*
All levels:						
(1) Low R&D funding	65.2	7.1	21.9	9.2	4.6	22.4
(2) High R&D funding	66.8	7.7	22.5	9.3	4.8	22.5
(3) Graduate faculty[a]	25.1	–.7	8.8	4.7	1.2	11.1
(4) Undergraduate faculty	36.2	6.0	11.6	4.4	3.1	11.1
Postdoctorates:						
(5) Low R&D funding	3.9	1.8	1.5	.1	.3	.2
(6) High R&D funding	5.5	2.4	2.1	.2	.5	.3

[a]Graduate faculty are defined as all individuals of academic rank of instructor or above who are significantly involved in the academic graduate program; i.e., teaching one or more graduate courses or seminars and/or directing research of one or more graduate students. Also included under graduate faculty for purposes of this study are nonteaching or research faculty.

Table C-2.—R&D EXPENDITURES BY SOURCE AND PERFORMER, 1969 AND 1980
[Dollars in billions]

Source and performer	1969		1980 computed	1980 adjusted to 2.7 (1970 ratio)	1980 adjusted to 3.0	Percent
	Amount	Percent				
Total R&D performance	$26.2	100.0	$45.4	$40.2	$44.7	100.0
Federal Government	3.5	13.4	5.6	5.0	5.5	12.4
Industry	18.4	70.2	32.6	28.9	32.1	71.7
Universities and colleges	2.7	10.1	4.5	4.0	4.5	10.0
FFRDC's[a]	.7	2.8	1.2	1.1	1.1	2.5
Other nonprofit	.9	3.6	1.5	1.3	1.5	3.4
Federal R&D performance	15.0	100.0	24.0	21.2	23.6	100.0
Federal	3.5	23.4	5.6	5.0	5.5	23.4
Industry	8.6	57.1	13.7	12.1	13.5	57.1
Universities and colleges	1.6	10.4	2.5	2.2	2.5	10.4
FFRDC's[a]	.7	4.8	1.2	1.1	1.1	4.8
Other nonprofit	.6	4.3	1.0	.9	1.0	4.3
Federal R&D/total R&D	*57.2*		*52.8*	*52.8*	*52.8*	
Federal R&D/unified budget outlays	*8.1*		*8.0*	*7.1*	*7.9*	
Total R&D/GNP	*2.81*		*3.05*	*2.7*	*3.0*	

[a]Federally Funded Research and Development Centers.

Table C-3.—INCREMENTAL NONACADEMIC R&D UTILIZATION OF DOCTORATES DUE TO GROWTH, BY BROAD AREA OF SCIENCE, 1969-80
[In thousands]

Level of funding and absorption	Total	Physical sciences	Life sciences	Mathematics	Engineering	Social sciences
Assuming low R&D funding:[a]						
(1) Low doctorate absorption[b]	19.1	8.5	4.4	.3	3.7	2.2
(2) High doctorate absorption[c]	20.6	9.2	4.7	.3	4.0	2.4
Assuming high R&D funding:[d]						
(3) Low doctorate absorption[b]	27.1	12.5	5.8	.4	5.3	3.1
(4) High doctorate absorption[c]	29.2	13.6	6.3	.4	5.6	3.3

[a]1980 R&D funding is assumed to be 2.7 percent of the GNP.

[b]New positions due to growth during the 1969-80 period will be filled by doctorates at rates 10 percent higher than the doctorate-to-total-scientist ratios existing in 1969.

[c]New positions due to growth during the 1969-80 period will be filled by doctorates at rates 20 percent higher than the doctorate-to-total-scientist ratios existing in 1969.

[d]1980 R&D funding is assumed to be 3.0 percent of the GNP.

Table C-4.—INCREMENTAL NONACADEMIC UTILIZATION OF DOCTORATES IN ACTIVITIES OTHER THAN RESEARCH AND DEVELOPMENT DUE TO GROWTH, BY BROAD AREA OF SCIENCE, 1969-80

[In thousands]

Level of assumptions	*Total*	*Physical sciences*	*Life sciences*	*Mathematics*	*Engineering*	*Social sciences*
(1) Low estimate[a]	24.8	8.8	3.3	1.3	5.2	6.3
(2) High estimate[b]	39.9	15.0	5.1	1.8	8.6	9.5

[a]In addition to the low assumption about growth in utilization of doctorates in nonacademic activities other than research and development, this projection assumes the lower 1980 R&D funding projection and the lower rates of doctorate absorption into new and vacated positions.

[b]In addition to the high assumption about growth in utilization of doctorates in nonacademic activities other than research and development, this projection assumes the higher 1980 R&D funding projection and the higher rates of doctorate absorption into new and vacated positions.

Table C-5.—INCREMENTAL ACADEMIC UTILIZATION OF DOCTORATES DUE TO DEATH OR RETIREMENT, BY BROAD AREA OF SCIENCE, 1969-80

[In thousands]

Faculty level	*Total*	*Physical sciences*	*Life sciences*	*Mathematics*	*Engineering*	*Social sciences*
All levels	20.3	3.3	6.6	2.1	2.7	5.6
Graduate faculty[a]	9.9	1.6	2.9	1.0	2.0	2.4
Undergraduate faculty	10.4	1.7	3.7	1.1	.7	3.2

[a]Graduate faculty are defined as all individuals of academic rank of instructor or above who are significantly involved in the academic graduate program; i.e., teaching one or more graduate courses or seminars and/or directing research of one or more graduate students. Also included under graduate faculty for purposes of this study are nonteaching or research faculty.

Table C-6.—INCREMENTAL NONACADEMIC[a] R&D UTILIZATION OF DOCTORATES DUE TO DEATH OR RETIREMENT, BY BROAD AREA OF SCIENCE, 1969-80

[In thousands]

Level of absorption	*Total*	*Physical sciences*	*Life sciences*	*Mathematics*	*Engineering*	*Social sciences*
Low doctorate absorption[b]	9.2	4.9	1.4	.1	1.6	1.2
High doctorate absorption[c]	10.1	5.4	1.5	.1	1.8	1.3

[a]Includes Federally Funded Research and Development Centers attached to Universities and colleges.

[b]Positions vacated by death or retirement will be filled by doctorates at rates 10 percent higher than the doctoral-to-total-scientist ratios existing in 1969.

[c]Positions vacated by death or retirement will be filled by doctorates at rates 20 percent higher than the doctoral-to-total-scientist ratios existing in 1969.

Table C-7.—INCREMENTAL NONACADEMIC UTILIZATION OF DOCTORATES IN ACTIVITIES OTHER THAN RESEARCH AND DEVELOPMENT DUE TO DEATH OR RETIREMENT, BY BROAD AREA OF SCIENCE, 1969-80

[In thousands]

	Total	*Physical sciences*	*Life sciences*	*Mathematics*	*Engineering*	*Social sciences*
Total	3.5	1.2	.5	.2	.6	1.0

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